RESEARCH PAPER

Human Vaccines & Immunotherapeutics 11:1, 72–82; January 2015; © 2015 Landes Bioscience

Effectiveness of interventions that apply new media to improve vaccine uptake and vaccine coverage

A systematic review

Anna Odone[1,*], Antonio Ferrari[1], Francesca Spagnoli[1], Sara Visciarelli[1], Abigail Shefer[2], Cesira Pasquarella[1], and Carlo Signorelli[1]

[1]Department S.Bi.Bi.T.; Unit of Public Health; University of Parma; Parma, Italy; [2]Vaccine-preventable Diseases and Immunization, World Health Organization Regional Office for Europe; Copenhagen, Denmark

Keywords: vaccine preventable diseases, immunization, vaccine coverage, vaccine uptake, new media, social media, communication technology, interventions, systematic review

Background: Vaccine-preventable diseases (VPD) are still a major cause of morbidity and mortality worldwide. In high and middle-income settings, immunization coverage is relatively high. However, in many countries coverage rates of routinely recommended vaccines are still below the targets established by international and national advisory committees. Progress in the field of communication technology might provide useful tools to enhance immunization strategies.

Objective: To systematically collect and summarize the available evidence on the effectiveness of interventions that apply new media to promote vaccination uptake and increase vaccination coverage.

Design: We conducted a systematic literature review. Studies published from January 1999 to September 2013 were identified by searching electronic resources (Pubmed, Embase), manual searches of references and expert consultation.

Study setting: We focused on interventions that targeted recommended vaccinations for children, adolescents and adults and: (1) aimed at increasing community demand for immunizations, or (2) were provider-based interventions. We limited the study setting to countries that are members of the Organisation for Economic Co-operation and Development (OECD).

Main outcome measures: The primary outcome was a measure of vaccination (vaccine uptake or vaccine coverage). Considered secondary outcomes included willingness to receive immunization, attitudes and perceptions toward vaccination, and perceived helpfulness of the intervention.

Results: Nineteen studies were included in the systematic review. The majority of the studies were conducted in the US (74%, n = 14); 68% (n = 13) of the studies were experimental, the rest having an observational study design. Eleven (58%) reported results on the primary outcome. Retrieved studies explored the role of: text messaging (n.7, 37%), smartphone applications (n.1, 5%), Youtube videos (n.1, 5%), Facebook (n.1, 5%), targeted websites and portals (n.4, 21%), software for physicians and health professionals (n.4, 21%), and email communication (n.1, 5%). There is some evidence that text messaging, accessing immunization campaign websites, using patient-held web-based portals and computerized reminders increase immunization coverage rates. Insufficient evidence is available on the use of social networks, email communication and smartphone applications.

Conclusion: Although there is great potential for improving vaccine uptake and vaccine coverage by implementing programs and interventions that apply new media, scant data are available and further rigorous research—including cost-effectiveness assessments—is needed.

Introduction

Vaccine-preventable diseases (VPD) still represent a major cause of morbidity and mortality worldwide. The World Health Organization (WHO) estimates that every year 1.5 million children die from VPD; this represents 17% of all deaths in children under five years of age.[1] As an example, pneumococcal disease accounts for nearly 15 million cases and 500 000 deaths per year in children, Hepatitis B accounts for 2 billion cases and 600 000 deaths[2], this representing a large share of the global VPD burden. The burden of VPD impacts also on adolescents and adult

*Correspondence to: Anna Odone; Email: anna.odone@mail.harvard.edu
Submitted: 06/05/2014; Accepted: 06/11/2014; Published Online: 08/07/2014
http://dx.doi.org/10.4161/hv.34313

populations with life-threatening diseases such as influenza, meningitis and infection-associated cancers.[3,4]

Immunization is one of the most successful and cost-effective primary prevention tools; it is estimated that, globally, immunizations prevent between 2 and 3 million deaths every year.[3] This holds true not only in low-income regions[5] but also in high-income settings: in the United States, between 1888 and 2011, it is estimated that more than 100 million cases of infectious diseases have been prevented by vaccines.[6] In addition, recent data reported that vaccinating children results in substantial cost savings.[7]

In high and middle-income settings vaccination coverage is relatively high.[8] However, in many countries coverage rates are still below the targets established by international[9] and national advisory committees,[7] particularly for specific vaccinations.[9] For example, in several countries including Austria, Indonesia, Denmark, the United Kingdom, and Italy measles vaccination coverage is far below the Organisation for Economic Co-operation and Development (OECD) countries' average of 93.6%.[10] With regard to influenza vaccine in older populations, average coverage rate in OECD countries is less than 60%, this decreasing to 22% in Slovenia and the Czech Republic and to 1% in Estonia.[10]

Suboptimum vaccination coverage in such settings results from a variety of challenges and obstacles acting on different subgroups of the population and including, among others, increasing migration flows[5], the spread of the hesitancy in the general population of accepting vaccination for themselves and their children as well as among providers of vaccinating themselves and recommending vaccination for their patients.[11,12]

Increasing and maintaining vaccination coverage in children and adult populations is of fundamental importance to further decrease the burden of VPD and it has been identified as a public health priority.[9]

In 1999 a comprehensive systematic review of the literature conducted by Briss et al. assessed the effectiveness of different interventions to improve vaccination coverage among children, adolescents, and adults.[13] The approach to the review was developed around a conceptual framework that stratified population-based interventions to improve vaccine coverage by the outcomes that they attempted to influence and divided them into four different categories: (1) interventions to increase community demand for immunizations; (2) interventions that enhance access to immunization services; (3) interventions that mandate immunizations; and (4) provider-based interventions.

Its findings have been used to formulate evidence-based recommendations provided by the US Department of Health and Human Services' Guide to Community Preventive Services[23] that have been recently updated. Findings from the updated review can be found on the website: The Community Guide, http://www.thecommunityguide.org/vaccines/index.html.

Since then, in the last fifteen years, the field of information and communication technologies has flourished revolutionizing the processes of gathering, spreading and utilizing health information among healthcare providers, citizens and mass media.[14] As the number of subjects using the internet worldwide has increased by almost 570% in 2000–2012, reaching more than 2750 million users in 2013, new media have been proposed as effective tools to implement public health actions.[15] New media are means of mass communication, developed at the time of the web era and include, among others, smartphone and internet-based tools in opposition to "old" media such as television, radio, film, magazines, which are static representations of text and graphics without interactivity.[16] Patients can benefit from the use of new media through communication, education, information sharing, networking, receiving care and support, goal setting and tracking personal progress.[17] In line with that, , new media might offer potential to further improve immunization coverage, especially in middle and high-income countries. We are not aware of a systematic assessment that has yet been conducted or available in the literature on this topic. The aim of the current paper is to systematically collect, summarize and critically appraise the available evidence on the effectiveness of interventions that apply new media to promote vaccination uptake and increase vaccination coverage.

Methods

The review's methods were defined in advance following the Prepared Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[18]

Inclusion criteria

The term "new media" refers to on-demand access to content through digital devices, which provide the opportunity to participate and be actively involved, reply to other users and give feedback; new media are defined as *manipulated, networkable and interactive*.[16] Based on this definition, we included interventions that applied the following mobile phones and internet-based tools: text messaging, smartphone applications, email communications, social networks and portals such as Facebook and Twitter and Youtube, websites and blogs.

We considered vaccinations universally recommended for children, adolescents and adults in high-income settings as included in countries' national immunization schedules[19-21]: diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B, measles, mumps, rubella, *Haemophilus influenzae* b (Hib), varicella, pneumococcal vaccine, meningococcal vaccine, papillomavirus (HPV), and seasonal influenza vaccine. This report does not address vaccines recommended for people with specific medical conditions (e.g., asthma), vaccines for international travellers or healthcare professionals.[22]

Studies were included in the review if they met the following criteria: were conducted in countries that were members of the OECD; were original studies using an observational or experimental study design (guidelines, review, letters or editorials were excluded); were published in books or journals from January 1st 1999 to September 10th 2013; were written in English.

Outcome measures

The primary outcome of interest was a measure of vaccination: vaccine coverage or vaccine uptake.[13] Considered secondary outcomes included: willingness to get immunized/ to immunize

children, immunizationtiming, access to healthcare for immunization-related issues, willingness to use/adopt the intervention/tool, perceived benefits and barriers of the intervention/tool, rate of utilization of the assessed intervention/tool, opinion on the helpfulness of the intervention, perceived risk associated with the vaccine, attitudes/knowledge towards immunizations and/or diseases. Secondary outcomes were retrieved if available and relevant.

Search strategy

We searched the electronic databases Medline and Embase for original studies. In addition, further studies were retrieved from reference listing of relevant articles and consultation with experts in the field.

The search strategy was built using a combination of keywords for the two main axes of the research question: (1) the selected interventions: the ones applying new media; and (2) the selected vaccinations: universally recommended vaccines for children, adolescents or adults. Within each axis we combined keywords with the "OR" operator and we then linked the search strategies for the two axes with the "AND" operator. The complete list of keywords used is presented in **Table 1**. The search was limited to the selected study setting: OECD countries. For the PubMed search, the use of free text terms was combined with Medical Subject Heading (MeSH) terms.

Study selection and data extraction

Identified studies were independently reviewed for eligibility by three authors (AF, FS, SV) in a two-step based process; a first screen was performed based on title and abstract while full texts were retrieved for the second screen. At both stages disagreements by reviewers were resolved by consensus.

Data were extracted by three authors (AF, FS, SV) supervised by a fourth author (AO) using a standardised data extraction spreadsheet. Data extraction was performed independently by two review authors. The data extraction spreadsheet was piloted on 10 randomly selected papers and modified accordingly. Data extraction included study characteristics such as: (1) authors' name, year, country of publication, study design, study setting, study period and study population; (2) the vaccines considered; (3) information about the intervention being studied such as: type of intervention, type of new media applied, duration of the intervention; (4) information on follow-up time, analysis performed and outcomes of interest.

Analysis

We performed descriptive analysis to report the characteristics of the included studies.

Adhering to the same conceptual framework applied in the past by The Community Preventive Services Task Force, that stratified interventions by the outcomes that they attempt to influence,[23] we assessed whether new media were applied to enhance or make more efficient: (1) interventions to increase community demand for immunizations; and (2) provider-based interventions.

To summarize the findings on the effectiveness of an intervention across multiple studies, we displayed the results of individual studies in tables. For every intervention, when a control was available (either in a "before and after design" or where the outcomes were also assessed in a control group) we planned to apply random effects analyses to acquire pooled estimates of the average effect and to assess heterogeneity using the I_2 statistic and visual inspection of forest plots.[24] Depending on data availability, we planned to conduct sub-group analyses (where relevant and possible) by vaccine, by study population and by age group. If unadjusted and adjusted outcomes were available, we recorded the adjusted estimates to reduce the risk of confounding.

Quality assessment

The same three authors who performed data extraction independently assessed the quality of selected studies using the methodological quality checklist developed by Downs and Black for both randomised and non-randomised studies of health care interventions.[25] Disagreements by reviewers were resolved by consensus. **Table 2** shows the quality assessment total score assigned to each study.

Results

Identified studies

We identified over 52 037 records by searching the selected databases and listing references of relevant articles. After removing duplicates, 37 634 abstracts were retrieved. Studies were screened and selected as illustrated in **Figure 1**, resulting in 156 full text articles assessed for eligibility and 19 studies that were included in the systematic review.

Table 1. Search strategy: keywords and limits

Axis 1 keywords
android, blog*, email*, facebook, forum*, internet, mobile phone*, new media, myspace, smartphone, sms, social media, social network*, text messag*, twitter, web, youtube,
Axis 2 keywords
coverage, immuniz*, rate*, vaccine*
Organisation for Economic Co-operation and Development countries[$]
Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States

[$]The search strategy was limited to OECD countries as study setting, human study populations and English language.

Table 2. Studies included in the systematic review

Reference	Country	Study design	Vaccine	Vaccine target population	New media applied in the intervention	Type of intervention	Study population*	Sample size (n)	Primary outcome assessed	Secondary outcome	Quality assessment score
Ahlers-Schmidt (a) 2012[52]	USA	Randomized controlled trial	Children recommended	Children	Text messages	Remind/recall	Parents	125	Yes	Timeliness of immunization, willingness to use/ adopt the intervention/ tool, perceived benefit and barriers of the intervention/tool, opinion on the helpfulness of the intervention	23
Ahlers-Schmidt (b) 2012[53]	USA	Cross-sectional study	Children recommended	Children	Text messages	Remind/recall	Parents	50	No	Willingness to use/ adopt the intervention/ tool, perceived benefit and barriers of the intervention/tool	10
Brunson 2013[54]	USA	Case-control study	Children recommended	Children	Internet - web surfing	Multicomponent interventions including education	Parents	196	Yes	-	15
Cooney 2010[55]	Ireland	Operational reserach	MMR	Students	Internet – email	Remind/recall	Students	177	No	Opinion on the helpfulness of the intervention	11
Coyle 2004[56]	USA	Non-randomized trial	Pneumococcal	Elders (> 65 y)	Standing order and computerized reminders	Provider-based interventions	Physicians, pharmacists	266	Yes	-	13
Dexheimer 2011[57]	USA	Operational reserach	Pneumococcal	Elders (> 65 y)	Computerized reminders	Provider-based interventions	Physicians	2062	Yes	-	20
Dexter 2004[58]	USA	Randomized controlled trial	Influenza and Pneumococcal	Elders (> 65 y)	Standing order and computerized reminders	Provider-based interventions	Physicians	1677	Yes	-	24
Hofstetter 2013[59]	USA	Cross-sectional study	Children recommended	Children	Text messages	Remind/recall	Parents, providers, medical staff	273	No	Opinion on the helpfulness of the intervention	11
Kharbanda 2011[60]	USA	Non-randomized trial	HPV	Adolescents	Text messages	Remind/recall	Parents	1512	Yes	-	18
Lau 2012[61]	Australia	Randomized controlled trial	Influenza	Students and university staff	Internet - online portal	Client-held medical records	Students, university staff	855	Yes	Access to healthcare, attitudes/knowledge towards immunization and/or disease	17
Loo 2011[62]	USA	Non-randomized trial	Influenza and Pneumococcal	Elders (>65 y)	Computerized reminders	Provider-based interventions	Physicians	4660	Yes	-	20

Table 2. Studies included in the systematic review (continued)

Reference	Country	Study design	Vaccine	Vaccine target population	New media applied in the intervention	Type of intervention	Study population*	Sample size (n)	Primary outcome assessed	Secondary outcome	Quality assessment score
Mena 2012[63]	Spain	Cross-sectional study	Influenza	Students	Internet, Facebook	Multicomponent interventions including education	Students	538	No	Willingness to use/adopt the intervention/tool	9
Mena 2013[64]	Spain	Non-randomized trial	Influenza	Students	Internet, website	Multicomponent interventions including education	Students	538	No	Willingness to get immunized/to immunize their children	14
Moniz 2013[65]	USA	Randomized controlled trial	Influenza	Pregnant women	Text messages	Multicomponent interventions including education	Pregnant women	216	Yes	Rate of utilization of the assessed intervention/ tool, opinion on the helpfulness of the intervention	3
Nan 2012[66]	USA	Randomized controlled trial	HPV	Students	Internet, blog	Multicomponent interventions including education	Students	341	No	-	24
Peck 2012[67]	USA	Operational reserach	Children recommended	Children	Smartphone application	Remind/recall multicomponent interventions including education	Parents	262	No	Rate of utilization of the assessed intervention/ tool, opinion on the helpfulness of the intervention	3
Robichaud 2012[68]	Canada	Non-randomized trial	Influenza	Students	Internet, Youtube	Multicomponent interventions including education	Students	250	No	Willingness to get immunized/to immunize their children, attitudes/ knowledge towards immunization and/or disease	18
Stockwell (a) 2012[69]	USA	Randomized controlled trial	Meningococcal and DTP (study1) *Haemphilus influenzae* b (study2)	Adolescents and parents	Text messages	Remind/recall	Parents	535	Yes	Access to healthcare	24
Stockwell (b) 2012[70]	USA	Randomized controlled trial	Influenza	Children	Text messages	Remind/recall multicomponent interventions including education	Parents	9213	Yes	-	24

*Who the outcomes were assessed on; DTP, Diphteria-Tetanus-Pertussis; MMR, Measles-Mumps-Rubella.

Characteristics of included studies

The characteristics of the included studies are reported in **Table 2**. Included studies were published between 2004 and 2013; 84% (n = 16) were published after 2010. The majority of the studies were conducted in the United States (US) (74%, n = 14). Overall, 89% (n = 17) were conducted in English-speaking countries, including, apart from the US, Australia,[26] Canada,[27] and Ireland.[28] Two studies were conducted in Spain.[29,30]

Of the studies, 68% (n = 13) had an experimental study design, the rest were observational studies. In particular, we considered seven randomized controlled trials,[26,31-36] five non-randomized trials,[27,30,37-39] three cross-sectional studies,[29,40,41] one case-control study,[42] and three studies that we considered to have an operational research approach.[37,43,44] Studies' sample size ranged from 50 to 9213 subjects (median = 341). One paper described two different studies.[35]

Five studies focused on childhood-recommended vaccines without listing specific vaccines.[31,40-42,44] Nine studies considered influenza vaccine,[26,27,29,30,32,33,35,36,39] three considered HPV vaccine,[34,35,38] one considered Diphtheria-Tetanus-Pertussis (DTP) vaccine,[35] four pneumococcal vaccine,[32,37,39,43] one Measles-Mumps-Rubella (MMR),[28] one meningococcal vaccine,[35] and one Hib[35] in different combinations.

Target populations for immunization were children in seven (37%) studies,[31,35,36,40-42,44] adolescents in two (10%),[35,38] adults in seven (37%)[26-30,33,34] and adults above 65 yeras of age in four (21%) papers.[32,37,39,43] Studies on adult vaccinations included university students in the majority of cases (86%, n = 6)[26-30,34] and one study focused on pregnant women.[33]

Eleven studies (58%) reported results on the primary outcome.[26,31-33,35-39,42,43] All randomized and non-randomized trials assessed the primary outcome. Twelve studies reported findings on secondary outcomes. Assessed secondary outcomes included: willingness to get immunized/ to immunize their children,[27,30,34] timeliness of immunization,[31,33] access to healthcare,[26,35] perceived risk associated with the vaccine,[34] attitudes/knowledge towards immunization and/or disease,[26,27,33,34] willingness to use/adopt the intervention/tool,[29,31,33,40] perceived benefits and barriers of the intervention/tool,[31,40] rate of utilization of the assessed intervention/tool,[44] opinion on the helpfulness of the intervention.[28,31,33,41,44] Four papers reported qualitative data.[26,28,31,40]

Due to high degree of heterogeneity between studies no quantitative assessment could be performed.

New media applied to interventions to increase community demand for immunizations

Text messaging

Retrieved studies

Seven studies reported findings on the use of text messages to improve immunization rates.[31,33,35,36,38,40,41] Text messaging can be applied to the following interventions: patients remind/recall[31,35,36,38,40,41] and multicomponent interventions including education.[33,36]

Retrieved studies were published between 2011 and 2013, all in the US. All studies were conducted in pediatric and community-based clinics in urban settings from 2009 to 2011.

Study populations

Study populations included parents of children[31,35,36,40,41] and adolescents,[35,38] pregnant women,[33] providers and medical staff.[41] In two studies the predominant ethnicity was white,[31,40] in others the percentage of latino ethnicity ranged from 42% to 85%.[35,36,41] In one study almost 70% of enrolled subjects were African American.[33] In studies where the data were reported the percentage of people with public insurance ranged from 58 to 90%.[31,33,35,36,38] Three studies targeted low socioeconomic status populations.[33,35,36]

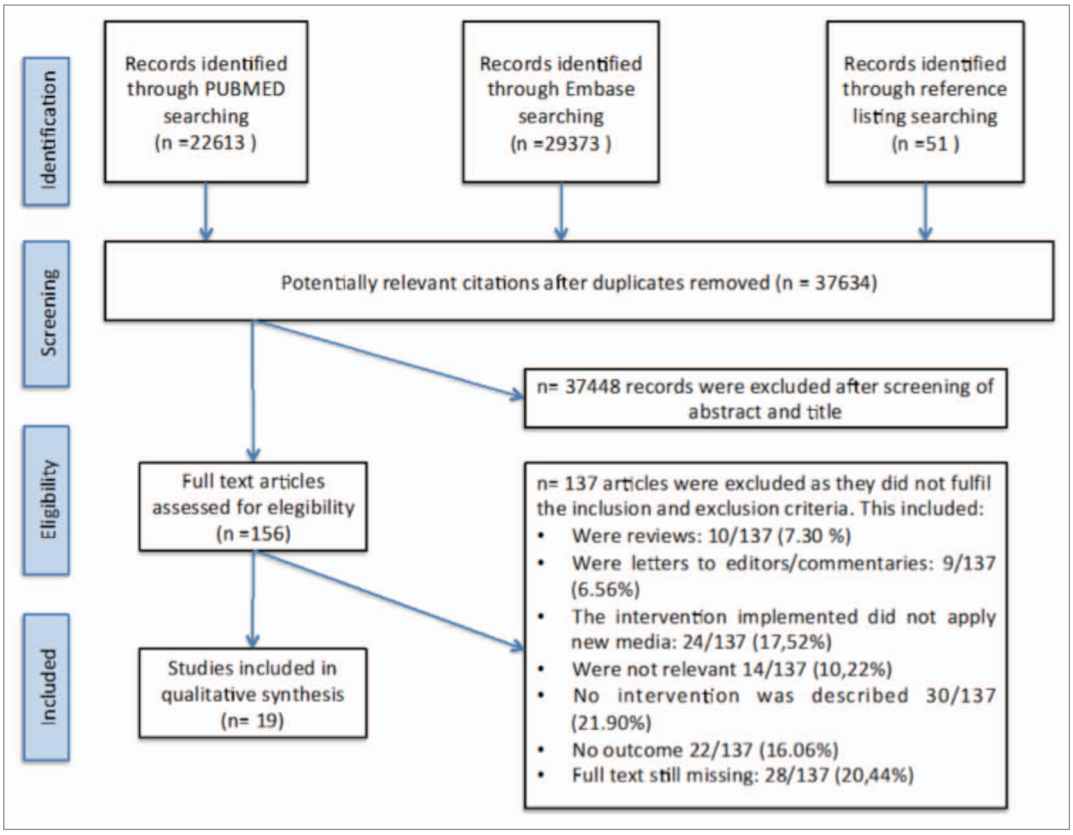

Figure 1. Prisma flowchart.

Data on health-related use

Sending or receiving health-related text messages is not yet common in routine public health practice.[40,41] Few parents reported ever receiving text messages to schedule an appointment (5%) or as a reminder of an existing appointment (31%).[41]

Interventions

In the included studies text messages were sent to parents and adolescents to remind pre-scheduled immunization visits,[31,35,38] to promote immunization in non-conformers adolescents[35] and to promote influenza vaccine uptake prior and during the influenza season.[33,36]

Reminder text messages included one text message sent to parents of newborns one week before the immunizations due date (scheduled at 2, 4, and 6 month of age),[31] three weekly text messages sent to parents whose daughters were due to have the second or third dose of HPV vaccine,[38] 12 weekly text messages encouraging pregnant women to get influenza vaccine[33] and up to three text messages sent two weeks before *Hib* immunization recall sessions.[35] Text messages targeting parents of immunization non-conformer adolescents were sent until vaccines were received up to 5 times.[35]

In all described interventions text messages were computer generated; in some cases text messages were personalized and were written in patients' preferred language[35,36,38] and included patients' name.[35] In one study they included educational messages targeted to patients' age.[36]

Outcomes

Five studies assessed the primary outcome[31,33,35,36,38] and five assessed secondary outcomes.[31,33,35,40,41] Studies with data on the primary outcome included four randomized and one non-randomized trial; in all studies vaccination status was assessed through immunization registries at different time points.

By the age of seven months, a higher percentage of due immunizations were received by children whose parents got reminder text messages as compared to children whose parents did not; this holding true for every assessed time point (2, 4, and 6-month-of-age; per protocol analysis: 100%, 93% 79% vs. 90%, 85%, 78%, respectively).[31]

On-time receipt of HPV vaccine was more frequent (51.6%) among girls whose parents signed up to receive the reminder text messages as compared with two control groups: an historical control group (38.1% $p = 0.003$) and parents who declined to receive the intervention (35%, $p = 0.001$). Similar results were reported when assessing receipt of HPV vaccine within 4 months of its due date.[38] Text messages sent to parents were proved to be effective to increase *Hib* and DTP vaccination intake in children at age 4 ($P < 0.001$), 12 ($P = 0.005$) and 24 weeks ($p < 0.001$) as well as to increase attendance to special immunization recall sessions as compared to standard mail reminder.[35]

Compliance with meningococcal and/or DTP immunization requirements was higher in non-conformer adolescents whose parents were sent text messages at all time points from randomization (percentage-point difference: 11.2%, 12.8% and 18.3% at 4, 12, and 24 weeks, respectively), the difference being statistically significant. Similar findings were reported when assessing receipt of any vaccine.[35] Text messages sent with both educational and reminder purposes were associated with higher influenza vaccine uptake at the end and during the influenza season in a large study conducted on over 9000 children (RR = 1.09, 95% CI, 1.04–1.15 and RR = 1.19, 95% CI, 1.10–1.28)[36] but had no effect in a smaller study conducted on pregnant women during the same study period.[33]

Studies assessing secondary outcomes reported that children whose parents received text message reminders were more likely to be immunized on time (although the difference was not statistically significant).[36]

Most of interviewed study participants indicated strong support of using text messages to schedule or confirm a vaccine appointment, as a reminder of an existing appointment or return for missed vaccines and expressed willingness to sign up for a text messaging reminder system.[31,40,41] One study conducted in the US reported that English-speaking parents were more comfortable than Spanish-speaking ones with health-related text messaging (99% vs 91%, $P = 0.05$).[41]

Perceived benefits of text messages reminder as emerged from qualitative data included: technology-related benefits such as interactivity,[41] ability to link to other systems/calendars and the speed with which information is available,[40] convenience-related benefits such as ease or timeliness of receiving reminders,[41] and easier communication.[41] Perceived barriers included technology-related issues such as lack of text capabilities, or not being technology-savvy; communication-related issues such as concerns regarding ability to understand text content, its limited characters, the use of abbreviations, or being provided inaccurate information. Some subjects worried about cell phone number accuracy and privacy, few worried about costs.[40,41] With regard to suggestions to improve the interventions, parents expressed interest in incorporating many patient, provider, visit, and vaccine-related details in the text messages, stated that more than one message should be sent and that preferred time to receive text messages was the afternoon.[40] One study assessed providers' opinion.[41]

Internet-based interventions

Retrieved studies

Seven studies reported findings on the use of the internet-based interventions to improve immunization coverage.[26-30,34,42] Internet is a potential useful tool to deliver interventions aimed at increasing community demand for immunizations, mainly through education and communication,[27,29,30,34,42] reminder/recall systems[28] and client-held medical records.[26] Included studies focused on how and how frequently internet was used to retrieve information on immunization[29,42] and how such information would positively or negatively influence immunization decision making.[27,30,34,42] In particular, some studies generally explored the rate of net surfing to seek immunization-related information,[29,40-42] while others focused on the role of specific immunization campaign websites and personalized portals,[26,27,29,30,34] blogs[34] and social media such as Youtube[27] and Facebook.[29]

Retrieved studies were published between 2010 and 2013, in Australia, Ireland, Spain and the US.

Study populations

Study populations were university students in the majority of the studies[26-30,34] and parents of children[42]; sample sizes ranging

from 177 to 588 subjects. Two papers described the same study population but different outcomes.[29,30]

Data on health-related use

As emerged from the included studies, the share of people actively browsing the internet to get information about immunizations is around 10% in different settings.[29,40] Frequency use of specific web portals including medical databases, government websites as well as Google, Youtube, and Wikipedia among university students was explored by one study conducted in Canada.[27]

Outcomes

Two studies assessed the primary outcome.[26,42]

One study was retrieved that described how internet can be used to manage and maintain client-held medical records.[26] It was a randomized controlled trial conducted in Australia exploring the efficacy of a personalized web-based portal on influenza vaccination uptake.[26] The portal integrated personal health records with consumer care pathways called "journeys", social forums and messaging tools that allowed consumers to interact with each other as well as with healthcare professionals. In particular, authors assessed the association between a specific influenza vaccine journey and vaccination rates during the study period. The influenza vaccine journey combined two elements: (1) an educational component that offered information on the influenza vaccine and how to get it; and (2) access to an online appointment booking system. Authors reported that subjects randomized to have access to the portal were 6.7% (95%CI: 1.46–12.30) more likely than people with no access to receive an influenza vaccine. In addition, they were also 11.6% (95%CI: 3.6–19.5) more likely to visit health service providers.

One descriptive study explored the use of electronic mail to improve vaccination uptake.[28] In particular, it reported on the usefulness of emails providing information on how and where to get vaccinated during a mumps outbreak in a university campus. More than 70% of interviewed students rated emails as the main sources of information about the vaccination and considered the use of emails as a very good/excellent source of information.[28]

One study conducted on US-born parents assessed the influence of source networks, including internet, on vaccination decision-making[42]; authors reported that parents conforming to the nationally recommended vaccination schedule (who have their children vaccinated completely and on time) were more likely to rank internet as the most important source in their networks as compared with non-conformer parents[42]. However, the type of webpages surfed and their content was not reported.

A survey conducted in Spain among medical students assessed the willingness to use Facebook as an education channel to promote influenza immunization. Around 90% of students reported to be Facebook users in the study population; nearly 70% were willing to "follow" either an official website promoting influenza immunization or the associated informal Facebook page, with a higher percentage of students preferring the informal Facebook page.[29] A non-randomized trial was conducted on the same study population to assess the association between being specifically exposed to online promotional campaigns and the willingness to get vaccinated against influenza. Authors reported that students who surfed the website of the national 2010/11 influenza campaign, containing technical information, videos and games promoting the vaccine, were almost 2.5 times more willing to get immunized as compared with students who received no intervention (OR: 2.42 95% CI: 1.16–5.03).[30]

In another experimental setting that compared the influence of blogs that both encouraged (positive) and discouraged (negative) HPV vaccination, it emerged how negative blogs have a negative impact on perceived vaccine efficacy, safety, and willingness to get vaccinated as compared with not being exposed to blogs' content while positive blogs seem not to have impact on such outcomes. In fact, while students randomly assigned to access negative blog later perceived the vaccine as less safe, held more negative attitudes toward the vaccine, and had reduced intentions to get vaccinated, exposure to the positive blog did not positively modify any vaccine-related risk perceptions, attitudes, or intentions. On the contrary, a study assessing the impact of popular YouTube vaccine-critical videos on medical students' attitudes towards influenza immunization reported no significant difference in pre to post video visualization attitudes towards influenza immunization, this holding true both for students exposed to 'evidence-based' presentation of vaccine-critical attitudes and videos focusing on anecdotal stories of harm.[27]

Smartphones' applications

Only one study was retrieved on smartphones' application applied to preventive health action in the field of immunization.[44] The study, conducted in the US and published in 2012, assessed parental uptake of an Android smartphone application that served as a reminder system for vaccinations and provided users with detailed information about children immunizations. However, data are not sufficient to evaluate the effectiveness and usefulness of the application as out of a convenience sample of parents, 45 subjects downloaded the application and only six completed the survey.

New media applied to provider-based interventions

Computerized reminders for providers and computer-based standing orders

Retrieved studies

Four studies were retrieved on computerized reminders for providers and computer-based standing orders.[32,37,39,43] They were published in 2004 and 2011, all in the US.

Study populations

All studies focused on influenza and/or pneumococcal vaccination in subjects over 65 y old in the emergency department,[43] impatient and primary care settings.[32,37,39] Sample size ranged from 266[37] to 4660[39] subjects.

Interventions

In the different studies patients eligible for influenza and pneumococcal vaccination were identified and standing orders and physician reminders were activated: semi-manually by querying the clinical information system and by patients' interview,[37] automatically through hospitals' computerized physician order entry systems[32] and integrating 4 different information systems, including the electronic medical record, the computerized triage application, the computerized provider order entry system, and the order tracking application.[43]

Outcomes

All studies reported data on the primary outcome. In inpatient and primary care settings, vaccination rates among eligible patients in the included studies ranged from 42% to 73% with standing orders[32,37] and from 15% to 59.7% with physician reminders,[32,37,39,43] these percentages being much higher compared to rates in control groups who received no intervention, providing evidence that both standing orders protocols and computerized reminders to physicians are effective strategies to increase vaccination rates.[37,39] In emergency department settings computerized reminder system increased vaccination rate from a baseline of 38.8% to 45.4%.[43]

Discussion

This is the first systematic assessment of the available evidence on the use of new media to increase vaccine uptake and immunization coverage. There are few studies in the published literature that assessed the effectiveness of interventions applying new media to increase immunization coverage and vaccination uptake. There is some evidence that text messaging, accessing immunization campaign websites, using patient-held web-based portals and computerized reminders and standing orders increase immunization coverage rates. Insufficient evidence is available on the use of social networks, email communication and smartphone applications. Although research on the topic is still scant, we report an increasing trend in publications as most of the retrieved papers were published after 2010.

In particular, text messaging might be used for reminder/recall purposes as well as to deliver immunization-related health education to parents of children and adolescents also in deprived socioeconomic settings. Despite the wide use of text messaging—it is estimated that young adults in the 18–29 y age group send and receive on average 87.7 sms per day[45]—we report limited use of such tools for health-related purposes. Considering mobile phones' ubiquity, portability and text messaging's relative low cost, their use might be successfully adapted to prevention programmes in the field of immunization[14]. Last but not least, some qualitative data are available on patients' preferences—including for example getting personalized messages with patients' name and in patients' mother tongue—that can be useful guides to successfully implement similar interventions in other settings.

While text messages are "one-way"-communication tools with limited potential for interaction and discussion, social media are internet-based "user-centered" applications that allow users' active role in the creation and exchange of information. We report that such features could be effectively applied to improve vaccination uptake. In fact, as emerged from a randomized controlled trial, having access to a personalized web-based portal where patients could manage health records as well as interact with both providers and others members of the community through social forums and messaging tools increased influenza vaccination uptake. [26] Email communication is widely used in social and professional settings because of its efficiency, versatility, user-friendliness and low cost[28] and it is likely that it will gradually replace traditional mail communication in prevention programs. However, there is insufficient evidence of its effectiveness to increase vaccine uptake.

Scant research is available on other forms of social media including smartphone applications and social networks. With regard to smartphone applications, the Centers for Disease Control and Prevention (CDC) and the WHO Regional Office for Europe have recently developed and launched two new smartphone applications. The CDC one is for clinicians and other immunization providers and aim to remind them the child, adolescent, and adult vaccines recommended by the Advisory Committee on Immunization Practice[22]; The WHO project targets parents and consists of a generic app code that countries can tailor into a smartphone application to remind parents when their children's vaccinations are due based on the country-specific immunization schedule.[46] Hopefully new data on the impact of such initiatives will be available soon.

With regard to social networks, we report students' willingness to use Facebook to seek health-related information. As the use of social networks is increasing—Eurostat data report that 86% of young people aged 16–24 y and 69% aged 16–24 are social networks subscribers[47]—it would be worth to further explore how they can be used to promote immunization.

On the other hand, as internet plays an increasingly central role in connecting people to information, the negative impact associated with the dissemination of negative or wrong messages regarding immunization has also alarmingly increased.[48] As emerged from the literature review anecdotally, "against-vaccination" blogs and websites are effective in discouraging people to get vaccinated or not to conform to recommended immunization schedules underlining how the potential harm of bad communication in the new media era is a public health concern.

The use of new media is differentially distributed worldwide and in different age groups and these patterns are reflected in the study settings and study populations of the included papers that cluster around, respectively, the US and young populations. This might hinder the generalizability of the results to the population level; however the impact of interventions applying new media is likely to be higher where the prevalence of new media use is high. Interventions that apply internet-based tools seem to be more suitable for young adults, in particular university students and, consequently, for vaccines targeting such age groups.[46] Of note, there is some evidence that such target populations might be more sensitive to immunization promotion messages informally delivered through social media as compared to highly technical messages.[29]

The role of new media in other fields of public health has been explored.[49-51] A recent systematic review assessed the effectiveness of new media-based interventions to promote healthy sexual behaviours among young adults and reported promising findings.[49] Similar research has been conducted in the field of health education for cancer patients.[50,51] There is some evidence that internet or interactive computer-based health education programmes in breast cancer patients increase health knowledge but not other outcomes.[50] Another systematic review retrieved poor

evidence on the effectiveness of using new media in prevention programmes targeting underserved subgroups of the population.[51]

Our review has limitations. These are mainly linked to limitations of the original studies. There was a high degree of heterogeneity between studies in terms of study setting, study populations, data collected, methods applied and exposure and outcomes assessed which limited the potential of quantitatively pooling estimates and findings and to conduct subgroups analysis. In addition, many studies had limited sample sizes, reported only descriptive analysis, had no control groups and did not assess the primary outcome not allowing to assess the impact of the interventions of interest. More than half of included studies had observational study designs which are at higher risk of reporting partly biased results. Data on some new media were not available and no data were available about costs and cost effectiveness.

Unmet immunization coverage targets in some settings signal the need for innovative strategies. The field of information and communication technologies has grown exponentially in the last years and will continue to. New media are increasingly accessible to the general population. In this context, we report that they offer great potential to increase vaccine uptake and immunization coverage in high and middle-income settings. However, more research is needed to assess the effectiveness and cost-effectiveness of interventions applying new media and on how to successfully market constructive public health messages in the new communication era.

Disclosure of Potential Conflicts of Interest

The authors alone are responsible for the views expressed in this article and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated.

References

1. WHO. Immunization http://www.who.int/gho/immunization/en/.
2. WHO. Estimates of disease burden and cost-effectiveness http://www.who.int/immunization/monitoring_surveillance/burden/estimates/en/.
3. WHO. World Immunization Week http://www.who.int/campaigns/immunization-week/2014/event/en/.
4. Crosignani P, De Stefani A, Fara GM, Isidori AM, Lenzi A, Liverani CA, Lombardi A, Mennini FS, Palu' G, Pecorelli S, et al. Towards the eradication of HPV infection through universal specific vaccination. BMC Public Health 2013; 13:642; PMID:23845195; http://dx.doi.org/10.1186/1471-2458-13-642
5. Pang T. Vaccination in developing countries: problems, challenges and opportunities. Global Perspectives in Health Vol II
6. van Panhuis WG, Grefenstette J, Jung SY, Chok NS, Cross A, Eng H, Lee BY, Zadorozhny V, Brown S, Cummings D, et al. Contagious diseases in the United States from 1888 to the present. N Engl J Med 2013; 369:2152-8; PMID:24283231; http://dx.doi.org/10.1056/NEJMms1215400
7. Zhou F, Shefer A, Wenger J, Messonnier M, Wang LY, Lopez A, Moore M, Murphy TV, Cortese M, Rodewald L. Economic evaluation of the routine childhood immunization program in the United States, 2009. Pediatrics 2014; 133:577-85; PMID:24590750; http://dx.doi.org/10.1542/peds.2013-0698
8. WHO. Global health risks: mortality and burden of disease attributable to selected major risks. http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf 2009
9. WHO. Global vaccine action plan 2011-2020 http://www.who.int/immunization/global_vaccine_action_plan/GVAP_doc_2011_2020/en/, 2013.
10. OECD. Health at a Glance 2011- OECD Indicators www.oecd-ilibrary.org2014. (accessed 03 07).
11. ECDC. Review of the scientific literature on drivers and barriers of seasonal influenza coverage in the EU/EEA 2013
12. Schlipköter U, Flahault A. Communicable Diseases: Achievements and Challanges for Public Health. Public Health Rev 2010; 32:90-119
13. Briss PA, Rodewald LE, Hinman AR, Shefer AM, Strikas RA, Bernier RR, Carande-Kulis VG, Yusuf HR, Ndiaye SM, Williams SM; The Task Force on Community Preventive Services. Reviews of evidence regarding interventions to improve vaccination coverage in children, adolescents, and adults. Am J Prev Med 2000; 18(Suppl):97-140; PMID:10806982; http://dx.doi.org/10.1016/S0749-3797(99)00118-X
14. Amicizia D, Domnich A, Gasparini R, Bragazzi NL, Lai PL, Panatto D. An overview of current and potential use of information and communication technologies for immunization promotion among adolescents. Hum Vaccin Immunother 2013; 9:2634-42; PMID:23954845; http://dx.doi.org/10.4161/hv.26010
15. InternetWorldStats. Internet usage statistics www.internetworldstats.com/stats.htm.
16. Post LA, Vaca FE, Doran KM, Luco C, Naftilan M, Dziura J, Brandt C, Bernstein S, Jagminas L, D'Onofrio G. New media use by patients who are homeless: the potential of mHealth to build connectivity. J Med Internet Res 2013; 15:e195; PMID:24001876; http://dx.doi.org/10.2196/jmir.2724
17. Househ M. The use of social media in healthcare: organizational, clinical, and patient perspectives. Stud Health Technol Inform 2013; 183:244-8; PMID:23388291
18. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 2009; 339:b2700; PMID:19622552; http://dx.doi.org/10.1136/bmj.b2700
19. It S. I. Calendario Vaccinale per la Vita. http://www.societaitalianaigiene.org/site/new/images/docs/calendariovaccinale/2012/cvplv.pdf
20. CDC. Recommended Immunization Schedule for Persons Age 0 Through 18 Years www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html
21. NHS. The NHS vaccination schedule. http://www.nhs.uk/Conditions/vaccinations/Pages/vaccination-schedule-age-checklist.aspx (accessed 24/04/2014)
22. Center for Disease Control and Prevention. http://www.cdc.gov/vaccines/schedules/hcp/schedule-app.html
23. Briss PA, Rodewald LE, Hinman AR, Shefer AM, Strikas RA, Bernier RR, Carande-Kulis VG, Yusuf HR, Ndiaye SM, Williams SM; The Task Force on Community Preventive Services. Reviews of evidence regarding interventions to improve vaccination coverage in children, adolescents, and adults. Am J Prev Med 2000; 18(Suppl):97-140; PMID:10806982; http://dx.doi.org/10.1016/S0749-3797(99)00118-X
24. Higgins JPGS. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. In. 5.1.0 ed: The Cochrane Collaboration; 2011.
25. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health 1998; 52:377-84; PMID:9764259; http://dx.doi.org/10.1136/jech.52.6.377
26. Lau AY, Sintchenko V, Crimmins J, Magrabi F, Gallego B, Coiera E. Impact of a web-based personally controlled health management system on influenza vaccination and health services utilization rates: a randomized controlled trial. J Am Med Inform Assoc 2012; 19:719-27; PMID:22582203; http://dx.doi.org/10.1136/amiajnl-2011-000433
27. Robichaud P, Hawken S, Beard L, Morra D, Tomlinson G, Wilson K, Keelan J. Vaccine-critical videos on YouTube and their impact on medical students' attitudes about seasonal influenza immunization: a pre and post study. Vaccine 2012; 30:3763-70; PMID:22484293; http://dx.doi.org/10.1016/j.vaccine.2012.03.074
28. Cooney F, Ryan A, Schinaia N, Breslin A. Using electronic mail to improve MMR uptake amongst third level students. Ir Med J 2010; 103:72-4; PMID:20666068
29. Mena G, Llupià A, García-Basteiro AL, Aldea M, Sequera VG, Trilla A. The willingness of medical students to use Facebook as a training channel for professional habits: the case of influenza vaccination. Cyberpsychol Behav Soc Netw 2012; 15:328-31; PMID:22703040; http://dx.doi.org/10.1089/cyber.2011.0457
30. Mena G, Llupià A, García-Basteiro AL, Sequera VG, Aldea M, Bayas JM, Trilla A. Educating on professional habits: attitudes of medical students towards diverse strategies for promoting influenza vaccination and factors associated with the intention to get vaccinated. BMC Med Educ 2013; 13:99; PMID:23866902; http://dx.doi.org/10.1186/1472-6920-13-99

31. Ahlers-Schmidt CR, Chesser AK, Nguyen T, Brannon J, Hart TA, Williams KS, Wittler RR. Feasibility of a randomized controlled trial to evaluate Text Reminders for Immunization Compliance in Kids (TRICKs). Vaccine 2012; 30:5305-9; PMID:22750044; http://dx.doi.org/10.1016/j.vaccine.2012.06.058
32. Dexter PR, Perkins SM, Maharry KS, Jones K, McDonald CJ. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. JAMA 2004; 292:2366-71; PMID:15547164; http://dx.doi.org/10.1001/jama.292.19.2366
33. Moniz MH, Hasley S, Meyn LA, Beigi RH. Improving influenza vaccination rates in pregnancy through text messaging: a randomized controlled trial. Obstet Gynecol 2013; 121:734-40; PMID:23635672; http://dx.doi.org/10.1097/AOG.0b013e31828642b1
34. Nan X, Madden K. HPV vaccine information in the blogosphere: how positive and negative blogs influence vaccine-related risk perceptions, attitudes, and behavioral intentions. Health Commun 2012; 27:829-36; PMID:22452582; http://dx.doi.org/10.1080/10410236.2012.661348
35. Stockwell MS, Kharbanda EO, Martinez RA, Lara M, Vawdrey D, Natarajan K, Rickert VI. Text4Health: impact of text message reminder-recalls for pediatric and adolescent immunizations. Am J Public Health 2012; 102:e15-21; PMID:22390457; http://dx.doi.org/10.2105/AJPH.2011.300331
36. Stockwell MS, Kharbanda EO, Martinez RA, Vargas CY, Vawdrey DK, Camargo S. Effect of a text messaging intervention on influenza vaccination in an urban, low-income pediatric and adolescent population: a randomized controlled trial. JAMA 2012; 307:1702-8; PMID:22535855; http://dx.doi.org/10.1001/jama.2012.502
37. Coyle CM, Currie BP. Improving the rates of inpatient pneumococcal vaccination: impact of standing orders versus computerized reminders to physicians. Infect Control Hosp Epidemiol 2004; 25:904-7; PMID:15566021; http://dx.doi.org/10.1086/502317
38. Kharbanda EO, Stockwell MS, Fox HW, Andres R, Lara M, Rickert VI. Text message reminders to promote human papillomavirus vaccination. Vaccine 2011; 29:2537-41; PMID:21300094; http://dx.doi.org/10.1016/j.vaccine.2011.01.065
39. Loo TS, Davis RB, Lipsitz LA, Irish J, Bates CK, Agarwal K, Markson L, Hamel MB. Electronic medical record reminders and panel management to improve primary care of elderly patients. Arch Intern Med 2011; 171:1552-8; PMID:21949163; http://dx.doi.org/10.1001/archinternmed.2011.394
40. Ahlers-Schmidt CR, Chesser AK, Paschal AM, Hart TA, Williams KS, Yaghmai B, Shah-Haque S. Parent opinions about use of text messaging for immunization reminders. J Med Internet Res 2012; 14:e83; PMID:22683920; http://dx.doi.org/10.2196/jmir.1976
41. Hofstetter AM, Vargas CY, Kennedy A, Kitayama K, Stockwell MS. Parental and provider preferences and concerns regarding text message reminder/recall for early childhood vaccinations. Prev Med 2013; 57:75-80; PMID:23624252; http://dx.doi.org/10.1016/j.ypmed.2013.04.007
42. Brunson EK. The impact of social networks on parents' vaccination decisions. Pediatrics 2013; 131:e1397-404; PMID:23589813; http://dx.doi.org/10.1542/peds.2012-2452
43. Dexheimer JW, Talbot TR 3rd, Ye F, Shyr Y, Jones I, Gregg WM, Aronsky D. A computerized pneumococcal vaccination reminder system in the adult emergency department. Vaccine 2011; 29:7035-41; PMID:21784117; http://dx.doi.org/10.1016/j.vaccine.2011.07.032
44. Peck JL, Stanton M, Reynolds GE. Smartphone preventive health care: parental use of an immunization reminder system. J Pediatr Health Care 2014; 28:35-42; PMID:23195652; http://dx.doi.org/10.1016/j.pedhc.2012.09.005
45. Pew Reserach Center. http://www.pewinternet.org/files/old-media//Files/Reports/2011/Americans%20and%20Text%20Messaging.pdf?src=prc-number.
46. WHO Regional Office for Europe. http://www.euro.who.int/en/health-topics/Life-stages/child-and-adolescent-health/news/news/2013/04/new-app-will-help-parents-keep-track-of-their-childrens-vaccinations.
47. Eurostat. Digital agenda Scoreboard 2012.
48. Zimmerman RK, Wolfe RM, Fox DE, Fox JR, Nowalk MP, Troy JA, Sharp LK. Vaccine criticism on the World Wide Web. J Med Internet Res 2005; 7:e17; PMID:15998608; http://dx.doi.org/10.2196/jmir.7.2.e17
49. Ryhänen AM, Siekkinen M, Rankinen S, Korvenranta H, Leino-Kilpi H. The effects of Internet or interactive computer-based patient education in the field of breast cancer: a systematic literature review. Patient Educ Couns 2010; 79:5-13; PMID:19744817; http://dx.doi.org/10.1016/j.pec.2009.08.005
50. Thompson HS, Shelton RC, Mitchell J, Eaton T, Valera P, Katz A. Inclusion of underserved racial and ethnic groups in cancer intervention research using new media: a systematic literature review. J Natl Cancer Inst Monogr 2013; 2013:216-23; PMID:24395995; http://dx.doi.org/10.1093/jncimonographs/lgt031
51. Kaplan AM, Michael H. Users of the world, unite! The challenges and opportunities of social media. Bus Horiz 2010; 53:61; http://dx.doi.org/10.1016/j.bushor.2009.09.003
52. Ahlers-Schmidt CR, Chesser AK, Nguyen T, Brannon J, Hart TA, Williams KS, Wittler RR. Feasibility of a randomized controlled trial to evaluate Text Reminders for Immunization Compliance in Kids (TRICKs). Vaccine 2012; 30:5305-9; PMID:22750044; http://dx.doi.org/10.1016/j.vaccine.2012.06.058
53. Ahlers-Schmidt CR, Chesser AK, Paschal AM, Hart TA, Williams KS, Yaghmai B, Shah-Haque S. Parent opinions about use of text messaging for immunization reminders. J Med Internet Res 2012; 14:e83; PMID:22683920; http://dx.doi.org/10.2196/jmir.1976
54. Brunson EK. The impact of social networks on parents' vaccination decisions. Pediatrics 2013; 131:e1397-404; PMID:23589813; http://dx.doi.org/10.1542/peds.2012-2452
55. Cooney F, Ryan A, Schinaia N, Breslin A. Using electronic mail to improve MMR uptake amongst third level students. Ir Med J 2010; 103:72-4; PMID:20666068
56. Coyle CM, Currie BP. Improving the rates of inpatient pneumococcal vaccination: impact of standing orders versus computerized reminders to physicians. Infect Control Hosp Epidemiol 2004; 25:904-7; PMID:15566021; http://dx.doi.org/10.1086/502317
57. Dexheimer JW, Talbot TR 3rd, Ye F, Shyr Y, Jones I, Gregg WM, Aronsky D. A computerized pneumococcal vaccination reminder system in the adult emergency department. Vaccine 2011; 29:7035-41; PMID:21784117; http://dx.doi.org/10.1016/j.vaccine.2011.07.032
58. Dexter PR, Perkins SM, Maharry KS, Jones K, McDonald CJ. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. JAMA 2004; 292:2366-71; PMID:15547164; http://dx.doi.org/10.1001/jama.292.19.2366
59. Hofstetter AM, Vargas CY, Kennedy A, Kitayama K, Stockwell MS. Parental and provider preferences and concerns regarding text message reminder/recall for early childhood vaccinations. Prev Med 2013; 57:75-80; PMID:23624252; http://dx.doi.org/10.1016/j.ypmed.2013.04.007
60. Kharbanda EO, Stockwell MS, Fox HW, Andres R, Lara M, Rickert VI. Text message reminders to promote human papillomavirus vaccination. Vaccine 2011; 29:2537-41; PMID:21300094; http://dx.doi.org/10.1016/j.vaccine.2011.01.065
61. Lau AY, Sintchenko V, Crimmins J, Magrabi F, Gallego B, Coiera E. Impact of a web-based personally controlled health management system on influenza vaccination and health services utilization rates: a randomized controlled trial. J Am Med Inform Assoc 2012; 19:719-27; PMID:22582203; http://dx.doi.org/10.1136/amiajnl-2011-000433
62. Loo TS, Davis RB, Lipsitz LA, Irish J, Bates CK, Agarwal K, Markson L, Hamel MB. Electronic medical record reminders and panel management to improve primary care of elderly patients. Arch Intern Med 2011; 171:1552-8; PMID:21949163; http://dx.doi.org/10.1001/archinternmed.2011.394
63. Mena G, Llupià A, García-Basteiro AL, Aldea M, Sequera VG, Trilla A. The willingness of medical students to use Facebook as a training channel for professional habits: the case of influenza vaccination. Cyberpsychol Behav Soc Netw 2012; 15:328-31; PMID:22703040; http://dx.doi.org/10.1089/cyber.2011.0457
64. Mena G, Llupià A, García-Basteiro AL, Sequera VG, Aldea M, Bayas JM, Trilla A. Educating on professional habits: attitudes of medical students towards diverse strategies for promoting influenza vaccination and factors associated with the intention to get vaccinated. BMC Med Educ 2013; 13:99; PMID:23866902; http://dx.doi.org/10.1186/1472-6920-13-99
65. Moniz MH, Hasley S, Meyn LA, Beigi RH. Improving influenza vaccination rates in pregnancy through text messaging: a randomized controlled trial. Obstet Gynecol 2013; 121:734-40; PMID:23635672; http://dx.doi.org/10.1097/AOG.0b013e31828642b1
66. Nan X, Madden K. HPV vaccine information in the blogosphere: how positive and negative blogs influence vaccine-related risk perceptions, attitudes, and behavioral intentions. Health Commun 2012; 27:829-36; PMID:22452582; http://dx.doi.org/10.1080/10410236.2012.661348
67. Peck JL, Stanton M, Reynolds GE. Smartphone preventive health care: parental use of an immunization reminder system. J Pediatr Health Care 2014; 28:35-42; PMID:23195652; http://dx.doi.org/10.1016/j.pedhc.2012.09.005
68. Robichaud P, Hawken S, Beard L, Morra D, Tomlinson G, Wilson K, Keelan J. Vaccine-critical videos on YouTube and their impact on medical students' attitudes about seasonal influenza immunization: a pre and post study. Vaccine 2012; 30:3763-70; PMID:22484293; http://dx.doi.org/10.1016/j.vaccine.2012.03.074
69. Stockwell MS, Kharbanda EO, Martinez RA, Lara M, Vawdrey D, Natarajan K, Rickert VI. Text4Health: impact of text message reminder-recalls for pediatric and adolescent immunizations. Am J Public Health 2012; 102:e15-21; PMID:22390457; http://dx.doi.org/10.2105/AJPH.2011.300331
70. Stockwell MS, Kharbanda EO, Martinez RA, Vargas CY, Vawdrey DK, Camargo S. Effect of a text messaging intervention on influenza vaccination in an urban, low-income pediatric and adolescent population: a randomized controlled trial. JAMA 2012; 307:1702-8; PMID:22535855; http://dx.doi.org/10.1001/jama.2012.502